

## **UPDATE ON DEVELOPMENT OF POSTHARVEST PEST CONTROL TREATMENTS FOR NUTS, CITRUS AND TROPICAL FRUITS USING RF ENERGY**

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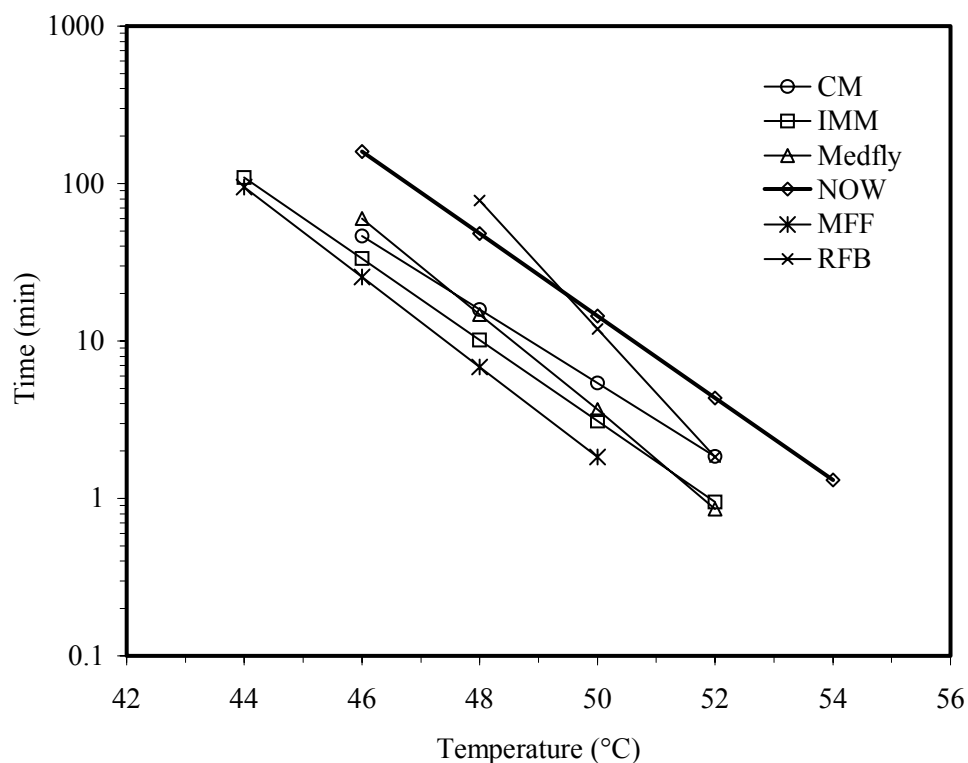
The decline in methyl bromide (MB) use since 1999 and phasing out of MB production by 2005 for most applications have forced the multi-billion dollar U.S. fruit and nut industries to seek alternatives for postharvest control of storage and quarantine insect pests. The need to develop effective and economically viable alternative phytosanitation and quarantine treatments is urgent in order for U.S. agriculture to maintain competitiveness in domestic and international markets. A comprehensive research and development program was launched in 2000 by a multi-disciplinary team of researchers in engineering, entomology and plant physiology and has since been supported by various programs including USDA IFAFS, USDA CSREES IREECGP Methyl Bromide Transitions Program, and USDA NRI programs, and by the California Walnut Marketing Board. The aim of this program was to develop knowledge and novel non-chemical treatments based on electromagnetic energy, in particular radio frequency (RF) energy. This presentation provides an update on the progress related to postharvest treatments for dried nuts, fresh citrus and tropical fruits.

For dried nuts, we have determined the thermal death kinetics of codling moth, Indianmeal moth, navel orangeworm and red flour beetle using the heating block system developed at Washington State University (Wang et al., 2002a,b; Johnson et al., 2003; 2004; Gazit et al., 2004) and found the fifth-instar navel orangeworm to be the most heat resistant insect (Fig. 1) when treatment temperatures are  $\geq 50^{\circ}\text{C}$ . With fiber-optic sensors, we measured temperatures 5-10°C higher in fifth-instar codling moth than in the host walnut kernels after 3 min heating with RF energy at 27.12 MHz to a final walnut temperature of 50°C (Fig. 2, Wang et al., 2003). This means that we can selectively heat and kill insect pests at lower nut temperatures, reducing treatment times, increasing product throughput, and reducing the effect on product quality. With proven differential heating of insects in walnuts at 27 MHz, we have developed a RF treatment protocol that completely kills the most heat resistant insects yet provides excellent walnut quality (Wang et al., 2002c; Mitcham et al., 2004). With intermittent stirring of the product during treatment, the temperature uniformity of walnuts after 3-min RF treatments was significantly improved (Fig. 3). We believe that this treatment is effective and economically viable. We are currently working with the walnut industry to transfer the laboratory treatment protocol to industrial applications.

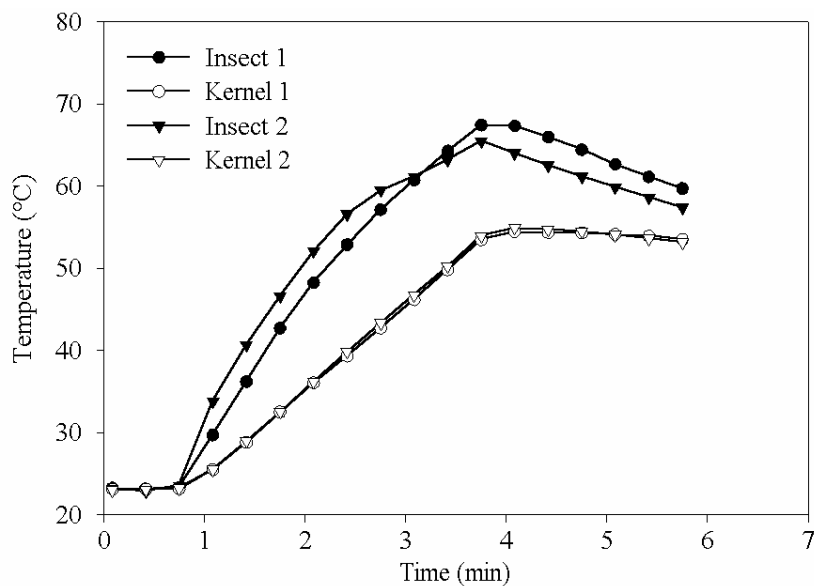
For citrus and tropical fruits, we have determined the minimum temperature-time combinations required to completely kill Mexican and Mediterranean fruit flies (Gazit et al., 2004), and studied means to provide uniform heating of fresh fruits in a system that can be used in large scale industrial applications (Birla et al., 2004). With rotation and movement of fruit, RF heating resulted in fairly uniform temperatures over the entire orange and achieved the target temperature in a short time (Fig. 4). Temperature uniformity in oranges was significantly improved with less than 2.8°C standard deviations after 5.5 min heating. With the hot water treatments, a large temperature gradient was observed from the surface to the core even after 20 min heating. We are now developing laboratory treatment protocol for oranges. Further research is needed to develop a large-scale continuous and economically viable process for the citrus and tropical fruit industries.

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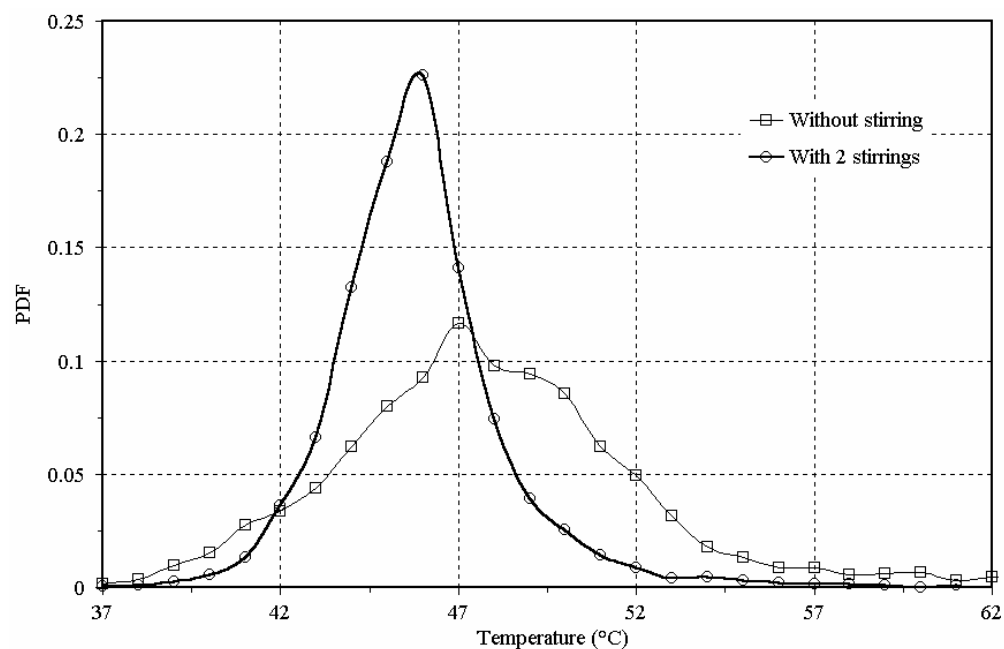
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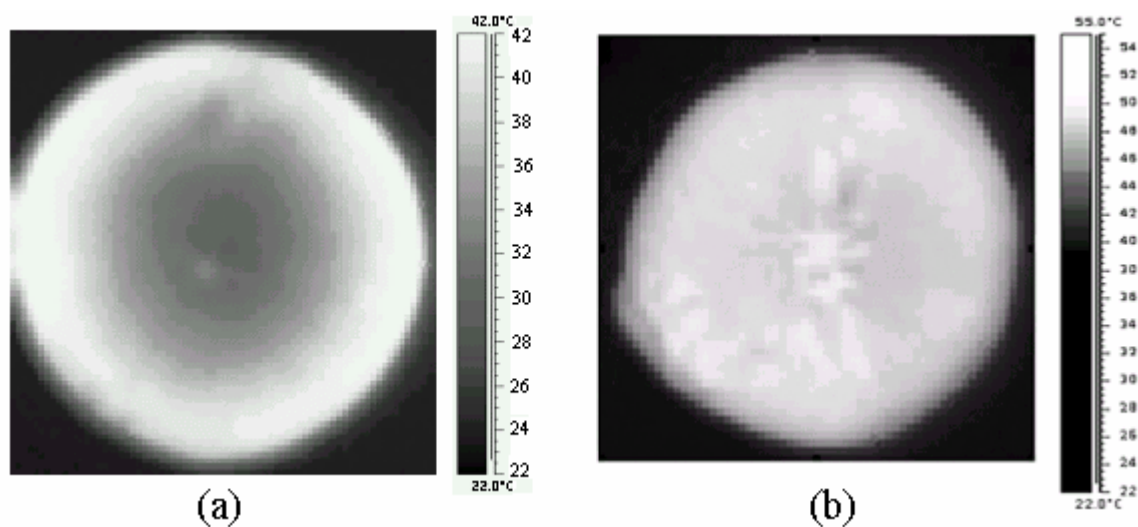
**Fig. 1.** Minimum time-temperature combinations for complete kill of 600 fifth-instar codling moth (CM), Indianmeal moth (IMM), navel orangeworm (NOW), third-instar red flour beetles (RFB), Mediterranean (Medfly) and Mexican fruit flies (MFF).



**Fig. 2.** Typical temperature profiles of walnut kernels and codling moth slurry when subjected to 27 MHz RF system ( $P = 0.67 \text{ kW/kg}$ )



**Fig. 3.** Distribution comparisons of probability density frequency (PDF) of walnut temperatures between without and with 2-intermittent stirrings after 3 min RF heating



**Fig. 4.** Temperature distributions in oranges (9 cm dia.) when subjected to hot water (a) at 53°C for 20 min and RF heating (b) for 5.5 min from 20 °C initial fruit temperature